1de set 1

1.

(a) A student made a solution of potassium hydroxide by dissolving 14.0 g of solid potassium hydroxide in distilled water to make 250 cm^3 of solution.

(i) Calculate the relative formula mass of potassium hydroxide, KOH.

.....

.....

(1)

(ii) Calculate the amount, in moles, of potassium hydroxide in 14.0 g.

.....

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(1)

(iii) Calculate the concentration, in mol dm^{-3}, of this solution of potassium hydroxide. Show your working.

.....

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(2)

(b) A different solution of potassium hydroxide, of concentration 2.0 mol dm^{-3}, was used in an experiment to react with carbon dioxide gas.

The equation for this reaction is

$$2KOH(aq) + CO_2(g) \rightarrow K_2CO_3(aq) + H_2O(l)$$

(i) Calculate the amount, in moles, of potassium hydroxide in 200 cm^3 of this solution.

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.....

(1)

(ii) Calculate the amount, in moles, of carbon dioxide that reacts with 200 cm^3 of this solution of potassium hydroxide.

.....

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(1)

(iii) Calculate the volume that this amount of carbon dioxide occupies at room temperature and pressure (rtp).
(molar volume of any gas = 24 dm^3 at rtp)

.....

.....

(1)

2.

One reaction that occurs in the blast furnace during the extraction of iron is the reaction between iron(III) oxide and carbon.

$$Fe_2O_3 + 3C \rightarrow 2Fe + 3CO$$

(a) Calculate the relative formula mass of iron(III) oxide, using information from the Periodic Table.

.....

(1)

(b) 320 kg of iron(III) oxide were added to the blast furnace.

(i) Calculate the amount, in moles, of iron(III) oxide added.

.....

.....

(2)

(ii) Calculate the maximum amount, in moles, of iron formed from this amount of iron(III) oxide.

.....

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(2)

(iii) Calculate the maximum mass, in kilograms, of iron formed from this amount of iron(III) oxide.

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(2)

3.

(a) A solution was made by dissolving 1.62 g of hydrogen bromide, HBr, in 250 cm^3 of water.

(i) Calculate the relative formula mass of hydrogen bromide. Use data from the Periodic Table on page 2.

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(1)

(ii) Calculate the amount, in moles, of hydrogen bromide in a 1.62 g sample.

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(2)

(iii) Calculate the concentration, in mol dm^{-3}, of the hydrogen bromide solution.

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(2)

(iv) Calculate the concentration, in g dm^{-3}, of the hydrogen bromide solution.

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(2)

(b) Hydrogen bromide solution can be neutralised by adding sodium hydroxide solution.
A 20.0 cm^3 sample of a solution of hydrogen bromide had a concentration of 0.200 mol dm^{-3}.

(i) Write a chemical equation for this neutralisation reaction.

.....

(1)

(ii) Explain, with reference to protons, why this reaction is described as a neutralisation reaction.

.....

.....

(2)

(iii) Calculate the amount, in moles, of hydrogen bromide in 20.0 cm^3 of 0.200 mol dm^{-3} solution.

.....

.....

(2)

(iv) Calculate the volume of 0.100 mol dm^{-3} sodium hydroxide solution needed to neutralise this sample of hydrogen bromide solution.

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(2)

4.

The chemical equation for Reaction 2 is

$$Ca(OH)_2 + 2HNO_3 \rightarrow Ca(NO_3)_2 + 2H_2O$$

A 14.8 g sample of calcium hydroxide is neutralised by a solution of nitric acid of concentration 1.6 mol dm^{-3}.

(i) Calculate the relative formula mass of calcium hydroxide and the amount, in moles, of calcium hydroxide in the 14.8 g sample.

(ii) Calculate the minimum volume, in cm^3, of this solution of nitric acid needed to neutralise the sample of calcium hydroxide.

(3)

(iii) Reaction 2 is used to prepare 0.050 moles of calcium nitrate.

Calculate the mass of this amount of calcium nitrate.

(2)

5.

25.0 cm^3 of dilute sulphuric acid are placed in a conical flask. A few drops of phenolphthalein indicator are added. The acid requires 8.70 cm^3 of sodium hydroxide solution of concentration 0.150 mol dm^{-3} for neutralisation.
The chemical equation for the reaction is

$$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$$

(i) What colour change is seen when the acid is neutralised?

.....

(2)

(ii) Calculate the amount, in moles, of sodium hydroxide used.

(2)

(iii) Calculate the amount, in moles, of sulphuric acid used.

(1)

(iv) Calculate the concentration, in mol dm^{-3}, of the sulphuric acid.

(1)

6.

Sodium carbonate is also formed when sodium hydrogencarbonate is heated strongly. The chemical equation for the reaction is

$$2NaHCO_3(s) \rightarrow Na_2CO_3(s) + H_2O(g) + CO_2(g)$$

4.2 g of sodium hydrogencarbonate is heated until it is fully decomposed.

(i) Calculate the amount, in moles, of sodium hydrogencarbonate used.

(3)

(ii) Calculate the amount, in moles, of carbon dioxide formed.

(1)

(iii) Calculate the volume, in dm^3, measured at room temperature and pressure (rtp), of carbon dioxide formed.
The volume of one mole of any gas at rtp is 24 dm^3.

(1)

7.

A 5.55 g sample of calcium chloride ($M_r = 111$) is dissolved in water to make a solution.

(i) Calculate the amount, in moles, in the sample of calcium chloride.

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(2)

(ii) What amount, in moles, of sulphuric acid is needed to react completely with the calcium chloride solution?

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(1)

(iii) Calculate the relative formula mass of calcium sulphate. Use data from the Periodic Table on page 2.

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(1)

(iv) Calculate the mass, in grams, of calcium sulphate formed.

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(2)

(c) The following equation represents a reaction used to prepare the salt lead(II) nitrate.

$$PbCO_3(s) + 2HNO_3(aq) \rightarrow Pb(NO_3)_2(aq) + H_2O(l) + CO_2(g)$$

In this experiment the amount of nitric acid used was 0.0400 mol.

(i) The concentration of the dilute nitric acid used was 0.500 mol dm^{-3}. Calculate the volume, in cm^3, of dilute nitric acid used.

(3)

(ii) In this experiment, 0.0200 mol of carbon dioxide gas was produced. Calculate the volume, in cm^3, that this amount of carbon dioxide occupies at room temperature and pressure (rtp).
(molar volume of any gas = 24 000 cm^3 at rtp)

(1)

11. The concentration of a solution of sodium hydroxide was found by titrating the solution with 0.200 mol dm^{-3} sulphuric acid.
25.0 cm^3 of the sodium hydroxide solution required 31.5 cm^3 of the sulphuric acid for complete reaction.

The equation for the reaction is

$$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$$

(a) (i) Explain why Universal indicator is not a suitable indicator for use in titrations.

.....

.....

(1)

(ii) Name a suitable indicator for this titration.

.....

(1)

(b) (i) Calculate the concentration, in mol dm^{-3}, of sodium hydroxide in the solution.

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(3)

(ii) Calculate the concentration, in g dm^{-3}, of sodium hydroxide in the solution.

(Relative atomic masses: H = 1.0; O = 16; Na = 23)

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(2)

Nov 2008

9. At a high temperature, calcium oxide reacts with carbon to form calcium carbide, CaC_2.

$$CaO(s) + 3C(s) \rightarrow CaC_2(s) + CO(g)$$

(a) Calcium oxide reacts with carbon to make 128 g of calcium carbide. Calculate

(i) the relative formula mass of calcium carbide.

(1)

(ii) the amount, in moles, of calcium carbide made in the reaction.

(1)

(iii) the minimum amount, in moles, of carbon that is required to make this amount of calcium carbide.

(1)

(iv) the minimum mass, in g, of carbon required.

(1)

Specimen paper

9. Much of the sulphur dioxide required for the manufacture of sulphuric acid is obtained from roasting metal sulphide ores such as zinc sulphide in air. The equation for this reaction is

$$2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$$

(a) Calculate the maximum volume of sulphur dioxide, measured at room temperature and atmospheric pressure, which would be released when 48.5 kg of zinc sulphide is roasted.
(Relative atomic masses: Zn = 65, S = 32)
(1 mol of a gas occupies 24.0 dm^3 at room temperature and atmospheric pressure.)

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(4)

(b) In the next stage of the process, the sulphur dioxide is converted into sulphur trioxide.

$$2SO_2 + O_2 \rightarrow 2SO_3$$

(i) What volume of sulphur trioxide, measured under the same conditions, is obtained from 1000 dm^3 of sulphur dioxide?

.....

(1)

(ii) What volume of oxygen, measured under the same conditions, would be used?

.....

(1)

Leave blank

(c) Magnesium oxide forms when magnesium burns in air.

$$2Mg(s) + O_2(g) \rightarrow 2MgO(s)$$

Describe what is observed when magnesium burns in air.

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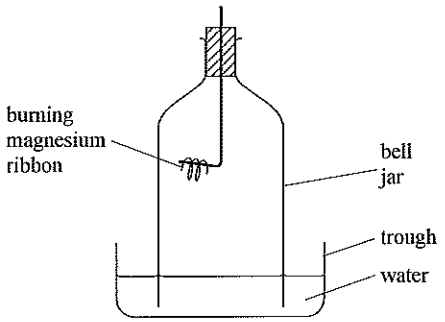
.....

(2)

(d) The following apparatus can be used to determine the percentage by volume of oxygen in the air.



(i) What is the approximate percentage by volume of oxygen in the air?

.....

(1)

(ii) The volume of air in the bell jar at the start of the experiment is 5.0 dm^3.

Use this volume and your answer to (d)(i) to calculate the amount, in moles, of oxygen molecules in the bell jar.
(The molar volume of a gas is 24 dm^3.)

(2)

10

(iii) Calculate the amount, in moles, of magnesium needed to react with this amount of oxygen.

(1)

(iv) Calculate the minimum mass, in grams, of magnesium needed to react with all the oxygen in the bell jar.

(2)

(Total 16 marks)

Leave blank

Q8

11

Leave blank

10. A student wanted to find the concentration of a solution of nitric acid.

She placed a 25.0 cm^3 sample of the nitric acid solution in a conical flask and titrated it with 0.200 mol dm^{-3} sodium hydroxide solution, using phenolphthalein as an indicator. The phenolphthalein changed colour after she added a total of 21.05 cm^3 of the sodium hydroxide solution.

The equation for the reaction is:

$$NaOH(aq) + HNO_3(aq) \rightarrow NaNO_3(aq) + H_2O(l)$$

(a) State the colour change of the phenolphthalein.

.....

.....

(2)

(b) (i) Calculate the amount, in moles, of sodium hydroxide used in the titration.

(2)

(ii) Calculate the concentration, in mol dm^{-3}, of the nitric acid.

(2)

12

Leave blank

(c) (i) Calculate the relative formula mass of sodium nitrate.

(1)

(ii) Calculate the mass of sodium nitrate formed in the titration.

(2)

(d) A solution of sodium nitrate was formed by neutralising some dilute nitric acid with aqueous sodium hydroxide.
Outline how you could obtain a dry sample of sodium nitrate crystals from the solution formed.

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(3)

Q10

(Total 12 marks)

12

Leave blank

10. Some reactions of calcium compounds are shown in this sequence.

$$CaO \xrightarrow{\text{Reaction 1}} Ca(OH)_2 \xrightarrow{\text{Reaction 2}} Ca(NO_3)_2 \xrightarrow{\text{Reaction 3}} CaCO_3$$

(a) What colour do calcium compounds give in a flame test?

.....

(1)

(b) What is added to calcium oxide in Reaction 1?

.....

(1)

(c) The chemical equation for Reaction **2** is

$$Ca(OH)_2 + 2HNO_3 \rightarrow Ca(NO_3)_2 + 2H_2O$$

A 14.8 g sample of calcium hydroxide is neutralised by a solution of nitric acid of concentration 1.6 mol dm^{-3}.

(i) Calculate the relative formula mass of calcium hydroxide and the amount, in moles, of calcium hydroxide in the 14.8 g sample.

(2)

Leave blank

(ii) Calculate the minimum volume, in cm^3, of this solution of nitric acid needed to neutralise the sample of calcium hydroxide.

(3)

(iii) Reaction **2** is used to prepare 0.050 moles of calcium nitrate.

Calculate the mass of this amount of calcium nitrate.

(2)

(d) Sodium carbonate solution is used as the reagent in Reaction **3**.

Write a chemical equation for the reaction and state **one** observation that can be made.

Equation .....

Observation .....

(3)

Q10

(Total 12 marks)

15

Leave blank

11. One reaction that occurs in the blast furnace during the extraction of iron is the reaction between iron(III) oxide and carbon.

$$Fe_2O_3 + 3C \rightarrow 2Fe + 3CO$$

(a) Calculate the relative formula mass of iron(III) oxide, using information from the Periodic Table.

.....

(1)

(b) 320 kg of iron(III) oxide were added to the blast furnace.

(i) Calculate the amount, in moles, of iron(III) oxide added.

.....

.....

(2)

(ii) Calculate the maximum amount, in moles, of iron formed from this amount of iron(III) oxide.

.....

.....

(2)

(iii) Calculate the maximum mass, in kilograms, of iron formed from this amount of iron(III) oxide.

.....

.....

(2)

16

1.

(a) A student made a solution of potassium hydroxide by dissolving 14.0 g of solid potassium hydroxide in distilled water to make 250 cm^3 of solution.

(i) Calculate the relative formula mass of potassium hydroxide, KOH.

56

(1)

(ii) Calculate the amount, in moles, of potassium hydroxide in 14.0 g.

0.25 moles (14/56)

(1)

moles = mass / molar mass

(iii) Calculate the concentration, in mol dm^{-3}, of this solution of potassium hydroxide. Show your working.

0.25 / 0.25 dm^3 = 1

(2)

conc = moles / volume (dm^3)

(b) A different solution of potassium hydroxide, of concentration 2.0 mol dm^{-3}, was used in an experiment to react with carbon dioxide gas.

The equation for this reaction is

$$2KOH(aq) + CO_2(g) \rightarrow K_2CO_3(aq) + H_2O(l)$$

(i) Calculate the amount, in moles, of potassium hydroxide in 200 cm^3 of this solution.

0.4 (= 2.0 x 0.2)

(1)

moles = vol x conc (dm^3)

(ii) Calculate the amount, in moles, of carbon dioxide that reacts with 200 cm^3 of this solution of potassium hydroxide.

0.2 (ratio in equation)

(1)

(iii) Calculate the volume that this amount of carbon dioxide occupies at room temperature and pressure (rtp).
(molar volume of any gas = 24 dm^3 at rtp)

0.2 x 24 dm^3 = 4.8 dm^3

(1)

volume = moles x 24 dm^3

2.

One reaction that occurs in the blast furnace during the extraction of iron is the reaction between iron(III) oxide and carbon.

$$Fe_2O_3 + 3C \rightarrow 2Fe + 3CO$$

(a) Calculate the relative formula mass of iron(III) oxide, using information from the Periodic Table.

160

(1)

(b) 320 kg of iron(III) oxide were added to the blast furnace.

1 kg = 1000 g

(i) Calculate the amount, in moles, of iron(III) oxide added.

320 kg = 320 000 g / 160
= 2000

(2)

(ii) Calculate the maximum amount, in moles, of iron formed from this amount of iron(III) oxide.

2000 x 2 = 4000

(2)

(iii) Calculate the maximum mass, in kilograms, of iron formed from this amount of iron(III) oxide.

4000 x 56 = 224 000 g (/ 1000)
= 224 kg

(2)

3.

(a) A solution was made by dissolving 1.62 g of hydrogen bromide, HBr, in 250 cm^3 of water.

(i) Calculate the relative formula mass of hydrogen bromide. Use data from the Periodic Table on page 2.

81

(1)

(ii) Calculate the amount, in moles, of hydrogen bromide in a 1.62 g sample.

1.62 / 81 = 0.02

(2)

(iii) Calculate the concentration, in mol dm^{-3}, of the hydrogen bromide solution.

0.02 / 0.25 dm^3 (= 250 cm^3 / 1000)

= 0.08

(2)

(iv) Calculate the concentration, in g dm^{-3}, of the hydrogen bromide solution.

0.08 × 81 = 6.5 g

mass = moles × molar mass

(2)

(b) Hydrogen bromide solution can be neutralised by adding sodium hydroxide solution.
A 20.0 cm^3 sample of a solution of hydrogen bromide had a concentration of 0.200 mol dm^{-3}.

(i) Write a chemical equation for this neutralisation reaction.

$HBr + NaOH \rightarrow NaBr + H_2O$

(1)

(ii) Explain, with reference to protons, why this reaction is described as a neutralisation reaction.

proton from HBr/acid to NaOH/alkali

(2)

(iii) Calculate the amount, in moles, of hydrogen bromide in 20.0 cm^3 of 0.200 mol dm^{-3} solution.

0.02 (= 20.0 cm^3) × 0.2 = 0.004

moles = conc × volume

(2)

(iv) Calculate the volume of 0.100 mol dm^{-3} sodium hydroxide solution needed to neutralise this sample of hydrogen bromide solution.

0.004 / 0.1 = 0.04 dm^3

volume = moles / concentration

(2)

4.

The chemical equation for Reaction **2** is

$$Ca(OH)_2 + 2HNO_3 \rightarrow Ca(NO_3)_2 + 2H_2O$$

1 : 2

$Ca(OH)_2 : HNO_3$

Use ratio!

A 14.8 g sample of calcium hydroxide is neutralised by a solution of nitric acid of concentration 1.6 mol dm^{-3}.

74 g

(i) Calculate the relative formula mass of calcium hydroxide and the amount, in moles, of calcium hydroxide in the 14.8 g sample.

14.8 / 74 = 0.2 moles

(ii) Calculate the minimum volume, in cm^3, of this solution of nitric acid needed to neutralise the sample of calcium hydroxide.

moles $Ca(OH)_2$ = 0.2

∴ moles HNO_3 = 0.2 × 2 = 0.4 moles

volume = moles / concentrat.

= 0.4 / 1.6 = 0.25 dm^3

(3)

(iii) Reaction **2** is used to prepare 0.050 moles of calcium nitrate.

Calculate the mass of this amount of calcium nitrate.

M_r = 164

0.05 × 164 = 8.2 g

(2)

5.

25.0 cm^3 of dilute sulphuric acid are placed in a conical flask. A few drops of phenolphthalein indicator are added. The acid requires 8.70 cm^3 of sodium hydroxide solution of concentration 0.150 mol dm^{-3} for neutralisation.
The chemical equation for the reaction is

$$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$$

(i) What colour change is seen when the acid is neutralised?

colourless to pink

(2)

(ii) Calculate the amount, in moles, of sodium hydroxide used.

0.150 X 0.0087 dm^3

= 0.00131

(2)

(iii) Calculate the amount, in moles, of sulphuric acid used.

0.00131 : 2 =

0.000653

(1)

(iv) Calculate the concentration, in mol dm^{-3}, of the sulphuric acid.

0.000653 / 0.025

= 0.0261

(1)

$CaCl_2^{(aq)} + H_2SO_4(aq) \rightarrow CaSO_4(aq) + 2HCl(aq)$

6.

Sodium carbonate is also formed when sodium hydrogencarbonate is heated strongly.
The chemical equation for the reaction is

$$2NaHCO_3(s) \rightarrow Na_2CO_3(s) + H_2O(g) + CO_2(g)$$

4.2 g of sodium hydrogencarbonate is heated until it is fully decomposed.

(i) Calculate the amount, in moles, of sodium hydrogencarbonate used.

$NaHCO_3$ = 84

moles = 4.2/84

= 0.05 moles

(3)

(ii) Calculate the amount, in moles, of carbon dioxide formed.

ratio $NaHCO_3 : CO_2$ = 2 : 1

0.05 mols / 2 = 0.025 moles

(1)

(iii) Calculate the volume, in dm^3, measured at room temperature and pressure (rtp), of carbon dioxide formed.
The volume of one mole of any gas at rtp is 24 dm^3.

0.025 X 24 = 0.6

(1)

7.

A 5.55 g sample of calcium chloride (M_r = 111) is dissolved in water to make a solution.

(i) Calculate the amount, in moles, in the sample of calcium chloride.

5.55 / 111 = 005

(2)

(ii) What amount, in moles, of sulphuric acid is needed to react completely with the calcium chloride solution?

0.05

(1)

(iii) Calculate the relative formula mass of calcium sulphate. Use data from the Periodic Table on page 2.

136

(1)

(iv) Calculate the mass, in grams, of calcium sulphate formed.

136 x 0.05

6.8 g

(2)

(c) The following equation represents a reaction used to prepare the salt lead(II) nitrate.

$$PbCO_3(s) + 2HNO_3(aq) \rightarrow Pb(NO_3)_2(aq) + H_2O(l) + CO_2(g)$$

In this experiment the amount of nitric acid used was 0.0400 mol.

(i) The concentration of the dilute nitric acid used was 0.500 mol dm^{-3}. Calculate the volume, in cm^3, of dilute nitric acid used.

volume = 0.04 / 0.5

= 0.08 dm^3

= 80 cm^3

(3)

(ii) In this experiment, 0.0200 mol of carbon dioxide gas was produced. Calculate the volume, in cm^3, that this amount of carbon dioxide occupies at room temperature and pressure (rtp).
(molar volume of any gas = 24 000 cm^3 at rtp)

$HNO_3 : CO_2$

2 : 1

0.04 : 0.02 x 24 000

= 480 cm^3

(1)

Set 2

11. The concentration of a solution of sodium hydroxide was found by titrating the solution with 0.200 mol dm^{-3} sulphuric acid.
25.0 cm^3 of the sodium hydroxide solution required 31.5 cm^3 of the sulphuric acid for complete reaction.

The equation for the reaction is

$$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$$

(a) (i) Explain why Universal indicator is **not** a suitable indicator for use in titrations.

gradual change in colour

(1)

(ii) Name a suitable indicator for this titration.

phenolphthalein

(1)

(b) (i) Calculate the concentration, in mol dm^{-3}, of sodium hydroxide in the solution.

$conc = \frac{moles}{volume\ (in\ dm^3)}$

moles of H_2SO_4 = 0.2 × 0.0135

= 0.0063

× ratio 1 : 2

moles NaOH = 0.0063

× 2 = 0.0126

conc = $\frac{0.0126\ moles}{0.25\ dm^3}$ = 0.504

(3)

(ii) Calculate the concentration, in g dm^{-3}, of sodium hydroxide in the solution.

(Relative atomic masses: H = 1.0; O = 16; Na = 23)

20.16 g dm^{-3}

90.2 g

(convert moles into mass)

0.504

(2)

-2-

Nov 2008

9. At a high temperature, calcium oxide reacts with carbon to form calcium carbide, CaC_2.

$$CaO(s) + 3C(s) \rightarrow CaC_2(s) + CO(g)$$

(a) Calcium oxide reacts with carbon to make 128 g of calcium carbide. Calculate

(i) the relative formula mass of calcium carbide.

64

(1)

(ii) the amount, in moles, of calcium carbide made in the reaction.

$\frac{128\ g}{64\ g} = 2$ $\quad moles = \frac{mass}{molar\ mass}$

(1)

(iii) the minimum amount, in moles, of carbon that is required to make this amount of calcium carbide.

6 moles (use ratio in equation $CaC_2 : C = 1:3$)

(1)

(iv) the minimum mass, in g, of carbon required.

6 × 12 = 72 g

(1)

$moles = \frac{mass}{molar\ mass}$

Specimen paper

9. Much of the sulphur dioxide required for the manufacture of sulphuric acid is obtained from roasting metal sulphide ores such as zinc sulphide in air. The equation for this reaction is

$$2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$$

(a) Calculate the maximum volume of sulphur dioxide, measured at room temperature and atmospheric pressure, which would be released when 48.5 kg of zinc sulphide is roasted.
(Relative atomic masses: Zn = 65, S = 32)
(1 mol of a gas occupies 24.0 dm^3 at room temperature and atmospheric pressure.)

× moles of ZnS = 48.5(g) = 0.5

moles = mass / molar mass

× 1 : 1 ratio → 0.5 mole SO_2

× 0.5 × 24 = 12 dm^3

moles = volume(dm^3) / 24 dm^3

(4)

(b) In the next stage of the process, the sulphur dioxide is converted into sulphur trioxide.

$$2SO_2 + O_2 \rightarrow 2SO_3$$

(i) What volume of sulphur trioxide, measured under the same conditions, is obtained from 1000 dm^3 of sulphur dioxide?

1000 dm^3

(1)

(ii) What volume of oxygen, measured under the same conditions, would be used?

500 dm^3

(1)

gases react in the same volume ratios as mole ratios

$2SO_2 + O_2 \rightarrow 2SO_3$

1000 dm^3 500 dm^3 1000 dm^3

1. One reaction that occurs in the blast furnace during the extraction of iron is the reaction between iron(III) oxide and carbon.

$$Fe_2O_3 + 3C \rightarrow 2Fe + 3CO$$

(a) Calculate the relative formula mass of iron(III) oxide, using information from the Periodic Table.

56 × 2 = 112 3 × 16 = 48 = 160

(1)

(b) 320 kg of iron(III) oxide were added to the blast furnace.

(i) Calculate the amount, in moles, of iron(III) oxide added.

320 kg = 320 000 g =

(moles = mass / molar mass) 160 g = 2000 moles

(2)

(ii) Calculate the maximum amount, in moles, of iron formed from this amount of iron(III) oxide.

Fe_2O_3 : 2 Fe → 1 : 2 (ratios)

2000 : 4000 moles

(2)

(iii) Calculate the maximum mass, in kilograms, of iron formed from this amount of iron(III) oxide.

4000 moles × 56 g/mol

224 000 g

= 224 kg

(moles = mass / molar mass)

(2)

Leave blank

(c) Most of the carbon monoxide formed in the reaction in (b) is converted to carbon dioxide before it leaves the blast furnace.

(i) Explain how carbon monoxide acts as a poison.

combines with haemoglobin in red blood cells

(1)

(ii) During one period in the operation of the blast furnace, the amount of carbon dioxide released was 5000 moles.

Calculate the volume, in dm^3, that this amount of carbon dioxide would occupy at room temperature and pressure (rtp).

(The molar volume of a gas is 24 dm^3 at rtp.)

5000 × 24 moles = volume / 24 dm^3

= 120 000 dm^3 (gas)

(1)

(d) Write the chemical equation for the reaction in which iron(III) oxide is reduced by carbon monoxide.

$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

(2)

(e) (i) Limestone is added to the blast furnace to remove impurities. State the main impurity removed.

SiO_2

(1)

(ii) Write two chemical equations to show how limestone removes this impurity.

Equation 1 $CaCO_3 \rightarrow CaO + CO_2$

Equation 2 $CaO + SiO_2 \rightarrow CaSiO_3$

(2)

Q11

(Total 14 marks)

TOTAL FOR SECTION B: 75 MARKS

END

11. (a) A solution was made by dissolving 1.62 g of hydrogen bromide, HBr, in 250 cm^3 of water.

(i) Calculate the relative formula mass of hydrogen bromide. Use data from the Periodic Table on page 2.

81

(1)

(ii) Calculate the amount, in moles, of hydrogen bromide in a 1.62 g sample.

1.62/81 moles = mass / molar mass

= 0.02 moles HBr

(2)

(iii) Calculate the concentration, in mol dm^{-3}, of the hydrogen bromide solution.

conc = 0.02 / 0.250 = 0.08

concentration = moles / volume (dm^3)

(2)

(iv) Calculate the concentration, in g dm^{-3}, of the hydrogen bromide solution.

0.08 x 81

= 6.48 g dm^3

(2)

(b) Hydrogen bromide solution can be neutralised by adding sodium hydroxide solution.
A 20.0 cm^3 sample of a solution of hydrogen bromide had a concentration of 0.200 mol dm^{-3}.

(i) Write a chemical equation for this neutralisation reaction.

$HBr + NaOH \rightarrow NaBr + H_2O$

(1)

(ii) Explain, with reference to protons, why this reaction is described as a neutralisation reaction.

$H^+ + OH^-$ react to form water

(2)

(iii) Calculate the amount, in moles, of hydrogen bromide in 20.0 cm^3 of 0.200 mol dm^{-3} solution.

moles = 0.02 dm^3 x 0.2

= 0.004

(2)

(iv) Calculate the volume of 0.100 mol dm^{-3} sodium hydroxide solution needed to neutralise this sample of hydrogen bromide solution.

volume = 0.004 / 0.1 = 0.04 dm^3 = 40 cm^3

(2)

(v) Suggest the name of an indicator (other than litmus), and its colour change, that could be used to check when neutralisation was complete.

Name of indicator phenolphthalein

Colour change colourless → purple

(3)

(Total 17 marks)

Leave blank

Q11

Leave blank

(c) Magnesium oxide forms when magnesium burns in air.

$$2Mg(s) + O_2(g) \rightarrow 2MgO(s)$$

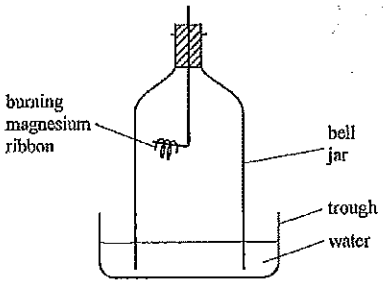
Describe what is observed when magnesium burns in air.

Bright white flame.

White ash

(2)

(d) The following apparatus can be used to determine the percentage by volume of oxygen in the air.



(i) What is the approximate percentage by volume of oxygen in the air?

21%

(1)

(ii) The volume of air in the bell jar at the start of the experiment is 5.0 dm^3.

Use this volume and your answer to (d)(i) to calculate the amount, in moles, of oxygen molecules in the bell jar.
(The molar volume of a gas is 24 dm^3.)

$\frac{21}{100} \times 5 = 1.05$

$n^o \text{ moles} = \frac{1.05}{24} = 0.04375$

$= 0.044$ (2)

Leave blank

(iii) Calculate the amount, in moles, of magnesium needed to react with this amount of oxygen.

$2Mg + O_2 \rightarrow 2MgO$

0.044

ratio 2 : 1

∴ n° moles Mg = 0.044 × 2 = 0.088 (1)

(iv) Calculate the minimum mass, in grams, of magnesium needed to react with all the oxygen in the bell jar.

$n^\circ \text{moles} = \frac{\text{mass}}{Ar}$

mass = 0.088 × 24

= 2.112 g

(2)

Q8

(Total 16 marks)

Leave blank

10. A student wanted to find the concentration of a solution of nitric acid.

She placed a 25.0 cm^3 sample of the nitric acid solution in a conical flask and titrated it with 0.200 mol dm^{-3} sodium hydroxide solution, using phenolphthalein as an indicator. The phenolphthalein changed colour after she added a total of 21.05 cm^3 of the sodium hydroxide solution.

The equation for the reaction is:

$$NaOH(aq) + HNO_3(aq) \rightarrow NaNO_3(aq) + H_2O(l)$$

(a) State the colour change of the phenolphthalein.

colourless ⇒ pink

(2)

(b) (i) Calculate the amount, in moles, of sodium hydroxide used in the titration.

$NaOH + HNO_3 \longrightarrow NaNO_3 + H_2O$

$0.200\ mol\ dm^{-3}$ $\frac{25}{1000}$ $\frac{21.05}{1000}$

$n^o\ moles = 0.2 \times \frac{21.05}{1000} = 0.00421$

(2)

(ii) Calculate the concentration, in mol dm^{-3}, of the nitric acid.

Ratio 1 : 1

$\therefore\ n^o\ moles = vol \times conc$

$conc = \frac{n^o\ moles}{vol}$

$= \frac{0.00421}{0.025}$

$= 0.168\ mol\ dm^{-3}$

(2)

Leave blank

(c) (i) Calculate the relative formula mass of sodium nitrate.

$Na(NO_3)$

$23 \quad 1 \quad 14 \quad (16 \times 3)$

$= 85$

(1)

(ii) Calculate the mass of sodium nitrate formed in the titration.

Moles $NaNO_3 = 0.00421 \times 85$

$= 0.35785$

(2)

(d) A solution of sodium nitrate was formed by neutralising some dilute nitric acid with aqueous sodium hydroxide.
Outline how you could obtain a dry sample of sodium nitrate crystals from the solution formed.

- Heat the solution to remove water
- cool and filter
- leave solution to crystallise.

(3)

(Total 12 marks)

Q10

Leave blank

10. Some reactions of calcium compounds are shown in this sequence.

$$CaO \xrightarrow{\text{Reaction 1}} Ca(OH)_2 \xrightarrow{\text{Reaction 2}} Ca(NO_3)_2 \xrightarrow{\text{Reaction 3}} CaCO_3$$

(a) What colour do calcium compounds give in a flame test?

Brick red

(1)

(b) What is added to calcium oxide in Reaction 1?

Water

(1)

(c) The chemical equation for Reaction 2 is

$$Ca(OH)_2 + 2HNO_3 \rightarrow Ca(NO_3)_2 + 2H_2O$$

A 14.8 g sample of calcium hydroxide is neutralised by a solution of nitric acid of concentration 1.6 mol dm^{-3}.

(i) Calculate the relative formula mass of calcium hydroxide and the amount, in moles, of calcium hydroxide in the 14.8 g sample.

$Ca(OH)_2 + 2HNO_3 \longrightarrow Ca(NO_3)_2 + 2H_2O$

R.F.M $Ca(OH)_2 = 40 + 32 + 2 = 74$ g mol^{-1}

n° moles $= \frac{\text{mass}}{M_F} = \frac{14.8}{74} = 0.2$ moles

(2)

Leave blank

11. One reaction that occurs in the blast furnace during the extraction of iron is the reaction between iron(III) oxide and carbon.

$$Fe_2O_3 + 3C \rightarrow 2Fe + 3CO$$

(a) Calculate the relative formula mass of iron(III) oxide, using information from the Periodic Table.

160 g mol^{-1}

(1)

(b) 320 kg of iron(III) oxide were added to the blast furnace.

(i) Calculate the amount, in moles, of iron(III) oxide added.

$\frac{32.0000}{160}$ = 2.000 moles

(2)

(ii) Calculate the maximum amount, in moles, of iron formed from this amount of iron(III) oxide.

ratio = 1 : 2

2000 : 4000 moles

(2)

(iii) Calculate the maximum mass, in kilograms, of iron formed from this amount of iron(III) oxide.

mass = moles x A$_r$

= 4000 x 56 = 224 kg

(2)

Leave blank

(c) Most of the carbon monoxide formed in the reaction in (b) is converted to carbon dioxide before it leaves the blast furnace.

(i) Explain how carbon monoxide acts as a poison.

reduces the blood's ability to carry oxygen.

(1)

(ii) During one period in the operation of the blast furnace, the amount of carbon dioxide released was 5000 moles.

Calculate the volume, in dm^3, that this amount of carbon dioxide would occupy at room temperature and pressure (rtp).

(The molar volume of a gas is 24 dm^3 at rtp.)

$n^o moles = \frac{vol}{24}$ $5000 \times 24 = 120,000\ dm^3$

(1)

(d) Write the chemical equation for the reaction in which iron(III) oxide is reduced by carbon monoxide.

$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

(2)

(e) (i) Limestone is added to the blast furnace to remove impurities. State the main impurity removed.

silica

(1)

(ii) Write two chemical equations to show how limestone removes this impurity.

Equation 1 $CaCO_3 \rightarrow CaO + CO_2$

Equation 2 $CaO + SiO_2 \rightarrow CaSiO_3$

(2)

Q11

(Total 14 marks)

TOTAL FOR SECTION B: 75 MARKS

END

Leave blank

9. At a high temperature, calcium oxide reacts with carbon to form calcium carbide, CaC_2.

$$CaO(s) + 3C(s) \rightarrow CaC_2(s) + CO(g)$$

(a) Calcium oxide reacts with carbon to make 128 g of calcium carbide. Calculate

(i) the relative formula mass of calcium carbide.

CaC_2

$40 + (12 \times 2) = 64$ (1)

(ii) the amount, in moles, of calcium carbide made in the reaction.

$n^0 \text{ moles} = \frac{128}{64} = 2$ (1)

(iii) the minimum amount, in moles, of carbon that is required to make this amount of calcium carbide.

ratio $C : CaC_2$

$3 : 1 \quad n^0 \text{ moles} = 6$

$6 : 2$ (1)

(iv) the minimum mass, in g, of carbon required.

$n^0 \text{ moles} = \frac{\text{mass}}{A_r} \quad \therefore \quad 6 \times 12 = 72\text{g}$ (1)

(b) Calcium carbide reacts with water to make the gas ethyne, C_2H_2, and a compound of calcium.

(i) Complete the chemical equation for this reaction:

$CaC_2 + 2H_2O \rightarrow C_2H_2 + \ldots Ca(OH)_2 \ldots$ (1)

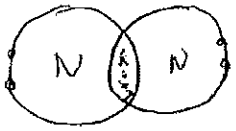
(ii) Ethyne, C_2H_2, is highly flammable.

Predict the products of the complete combustion of ethyne.

$C_2H_2 + \frac{5}{2}O_2 \longrightarrow 2CO_2 + H_2O$ (2)

Leave blank

(d) (i) Draw a dot and cross diagram to show the bonding in a nitrogen molecule.



(2)

(ii) How do the shared pairs of electrons hold the nitrogen molecule together?

The electrons are attracted to both nuclei

(1)

(e) Ammonia reacts with phosphoric acid to form a compound that contains 28.2% nitrogen, 8.1% hydrogen, 20.8% phosphorus and 42.9% oxygen by mass.

Calculate the empirical formula of this compound.

N	H	P	O
$\frac{28.2}{14}$	$\frac{8.1}{1}$	$\frac{20.8}{31}$	$\frac{42.9}{16}$
$\frac{2.01}{0.67}$	$\frac{8.1}{0.67}$	$\frac{0.67}{0.67}$	$\frac{2.68}{0.67}$
3	12	1	4

E.F = $N_3H_{12}PO_4$

(3)

Q10

(Total 15 marks)

TOTAL FOR SECTION B: 75 MARKS

TOTAL FOR PAPER: 120 MARKS

END